Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

THE PEACH TWIG BORER

The first obvious sign of attack on an almond shoot by a newly hatched larva of the twig borer

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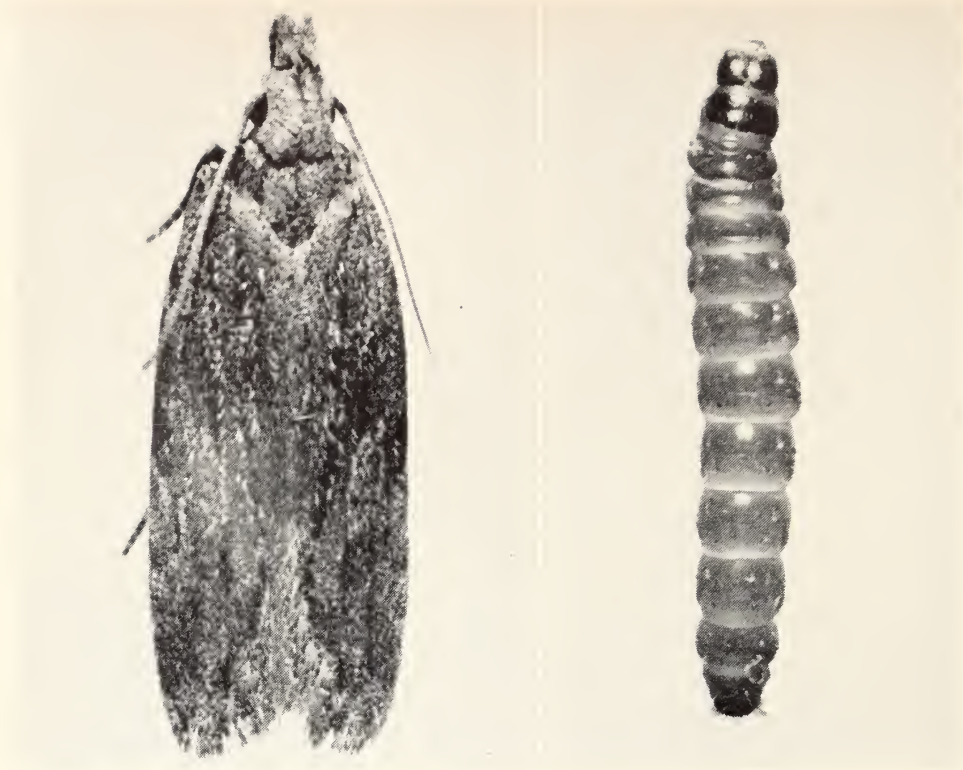
CALIFORNIA AGRICULTURAL
Experiment Station
Extension Service

CIRCULAR 449



The adult (or moth) phase of the peach twig borer on the left, and the mature larva. The moth is about 11 times natural size; the larva about 8 times.

This circular: tells you how it grows, and how to fight it.

Control is discussed from the standpoint of the best methods to use in different localities and at different times.

The peach twig borer (commonly called just "twig borer") is the chief cause of wormy peaches, nectarines, and almonds in California. In apricot, plum, and prune orchards it is one of several species of moths, any one of which can blemish or injure an appreciable amount of ripening fruit.

Replaces Bulletin 708

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NOVEMBER 1955

The PEACH TWIG BORER

F. M. SUMMERS

What it is • where it is found • the type and extent of damage it does to various California crops

THE PEACH TWIG BORER is a small moth. The larvae produced by the moth attack both twigs and fruit. Although only the larvae are truly twig borers, the name "peach twig borer" (or sometimes simply "twig borer") is used in reference to all stages of this species (*Anarsia lineatella* Zell.).

Disastrous outbreaks of the peach twig borer have occurred in past years, and there are few peach growers who are not acquainted with this cause of wormy fruit. The possibilities of fruit loss are so serious that protective sprays are regularly applied to peaches and nectarines. Economic losses of apricots, almonds, plums, and prunes occur less often; but, where local situations require, these hosts are also sprayed for twig borer.

Not a purely local pest

The peach twig borer is widely distributed throughout the United States. It is also known in Europe and Asia. Although all of the peach- and almond-producing areas of California are infested, this insect is particularly prevalent in the San Joaquin and Sacramento Valleys.

The principal host plants are the almond and peach. Other hosts are the apricot, nectarine, plum, and prune. The twig borer has never been found to attack any other crop or native plant in California.

The tiny larvae hatching in late summer hide themselves in cells—hibernacula—beneath the surface layers of bark. They are readily distributed in this condition on nursery stock, cuttings, and budwood. Commercial or ornamental varieties planted in city yards nearly always harbor their quota of twig borers.

Damage is extensive . . .

There are two kinds of damage: (1) destruction of buds and young shoots, and (2) worm damage on fruits.

Larvae hatched in late summer tunnel into the bark, especially in the crotches of older twigs, where they remain inactive during winter. In the spring, shortly before bloom, they become active and enlarge their tunnels or make new ones. Hatching larvae of the summer broods also may live temporarily in bark tunnels before moving onto green foliage. The mining of the bark by immature larvae does not appear to hurt the host plants.

The small overwintered larvae leave their tunnels during the blooming period. The first ones to emerge attack opening buds and starting shoots. The larvae grow as the foliage develops, and they usually kill the terminal shoots before

This overwintering cell (hibernaculum) with a well-developed chimney was found in the crotch between one- and two-year-old peach wood on November 1. It is magnified 5 times.

A partly dissected hibernaculum on three-year almond wood shows the shallow excavation in the fold of tender bark. A short chimney overlies this burrow. Arrow points to the head of the small larva. Magnified about 7 times.

they finish feeding. All of the hosts are affected in this manner. But the amount of twig die-back on mature trees, even in severe infestations, is not itself economically important. The real problem arises when some of the larvae leave the foliage and attack the fruit. The shoots of slower-growing varieties or non-irrigated trees harden-off early. Such hardening or woody twigs are less attractive to the larvae, and the fruits are increasingly liable to attack.

Young trees, replants, and grafts are especially attractive to twig borers. The terminal shoots in new plantings of peaches and almonds may be so severely injured that the trees are retarded or greatly distorted in shape. Whenever twig borer is prevalent, it is wise to spray non-bearing orchards to get well-shaped trees.

The damage to the fruits of all hosts except almonds is essentially the same. Attacks on fruit begin with "worms" of the May brood and are usually marked by "bleeding," or the presence of sap droplets on green almonds, plums, prunes, nectarines, peaches, and to a lesser extent apricots. The larvae often make several attempts to enter young, green fruits but are rarely able to do so at this stage of growth. Early-season injuries occur more often on double fruits and split-pits. The injury to fruits by worms of the May (first) generation is small in comparison with the damage caused by worms of the second or third generations during July and August. However, a bad situation can develop in apricots if the hatching of eggs of the May brood is delayed. In this case the rise of the worm population coincides with the ripening of early varieties.

Growers commonly speak of twig borer injury to ripening stone fruits as being caused by "stem-worms" or "skin-worms." The worms attack the majority of fruits near the stem end or at points of contact between two fruits. When they crawl about over trees seeking ripening

fruits, they usually migrate down the stems and usually enter the fruit at that point. Large larvae occasionally penetrate deeply into the flesh or kernel.

An increasingly great proportion of the small worms attack later-ripening varieties. They perforate the skin of the fruit, feed in shallow excavations, and are seldom more than one-third to one-half grown when the fruit is picked. As early varieties of fruit ripen and are harvested, the attack is intensified on later varieties. Destruction increases rapidly at this critical time, when applications of residual insecticides are not permissible because of the poison left on the fruit. Infested fruits dropped by pickers become more numerous as picking progresses.

The feeding of twig borer larvae on green almond hulls is of no concern, except of course that these individuals add to the density of the general infestation.

This almond shoot was attacked during May by a twig-feeding larva.

. . . and expensive to growers

Peaches. Since the peach twig borer was first discovered in California about 60 years ago, it has been an annual pest of importance. As early as 1887, a 50 per cent loss of peaches was experienced in some districts. The heaviest known loss from its attack occurred in 1931. Officials of the State Department of Agriculture reported an average of 10 per cent infestation in peaches harvested throughout the peach belt. Individual orchards around Yuba City ranged as high as 70 per cent wormy peaches. In more recent years there have been serious outbreaks in peaches, but these have been spotty and irregular in distribution.

Plums. The so-called stem-worms, or small larvae of the peach twig borer that attack plums at harvest time, usually appear when the early varieties begin to ripen. However, in delayed seasons, damage also occurs on late-maturing varieties, such as Kelsey, Grand Duke, and President. Even in the seasons of heavy infestation, the damage to the plum crop rarely exceeds 20 per cent. The amount of injury varies greatly in degree between areas and is difficult to predict.

Apricots. The amount of twig borer injury to ripening apricots follows the pattern of the situation described for plums. Worm damage to apricots is usually more severe in years of light crops.

Sugar prunes injured by twig borer.

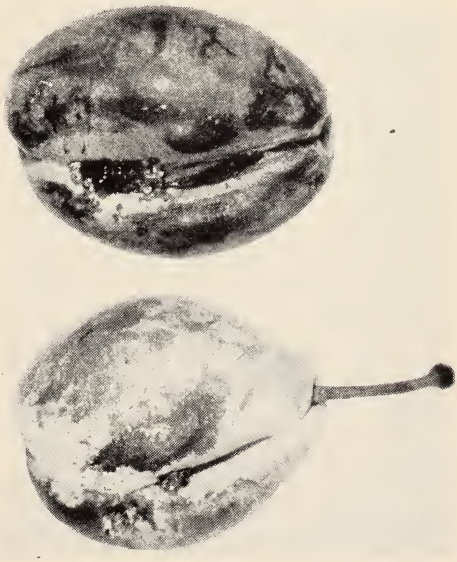


Table 1. Losses of Nonpareil Almonds Caused by Peach Twig Borer, 1933–52*

Year	Total California almond production	Approx. amt. of in-shell Nonpareil almonds based on deliveries to Exchange	Nonpareil meats based on estimated average meat content of 60 per cent	Worm-cut meats of Nonpareils from Exchange shelling operations	Average in-shell returns to Exchange members for Nonpareil variety	Shelled equivalent return based on 60 per cent meat content	Calculated amount of loss based on one-third recovery
	tons	tons	tons	per cent by wt.	cents per lb.	cents per lb.	dollars
1933	12,900	3,870	2,322	1.20	13.0	21.7	8,052
1934	10,900	3,706	2,223	1.34	14.8	24.6	9,771
1935	9,300	3,348	2,008	3.36	20.2	33.7	30,303
1936	7,600	2,204	1,322	5.89	27.5	45.8	47,585
1937	20,000	7,000	4,200	1.19	17.2	28.7	19,142
1938	15,000	4,800	2,880	7.49	15.5	25.8	74,204
1939	19,200	7,296	4,377	0.34	13.5	22.5	44,649
1940	10,200	3,264	1,958	4.53	19.7	32.8	38,810
1941	5,000	1,850	1,110	8.34	44.4	74.0	91,366
1942	22,000	8,800	5,280	1.00	26.7	44.5	31,310
1943	16,000	5,120	3,072	1.90	44.9	74.8	58,185
1944	21,000	9,450	5,670	1.20	44.9	74.8	67,836
1945	23,800	9,044	5,426	0.30	44.7	74.5	16,156
1946	37,800	14,969	8,981	0.18	30.8	51.3	11,044
1947	29,200	10,658	6,395	0.32	34.4	57.3	15,614
1948	36,500	15,184	9,110	1.02	26.4	44.4	54,452
1949	43,300	16,540	9,924	1.06	23.2	38.7	54,195
1950	37,700	15,269	9,162	1.43	34.2	57.0	99,441
1951	42,700	18,190	10,914	2.30	30.3	50.5	168,938
1952	36,400	12,194	7,316	3.30	28.5	47.5	152,904

* Data supplied by California Almond Growers Exchange.

Almonds. The losses of almonds to peach twig borer are of greatest significance for the soft-shell varieties, the kernels of which are chewed or scarred during the interval between husk-split and harvest. The meaning of this pest to the almond industry is shown in the data of table 1. This 20-year record of production and grade-out was compiled for this publication by the California Almond Growers Exchange. The dollar losses are compiled for almonds of the Nonpareil variety only, on the basis of shelling operations at the Exchange plant. Ne Plus, IXL, and other susceptible varieties are not included.

Growth stages and habits of the peach twig borer • area problems • discussion of the oriental fruit moth

Good management of twig borer infestations requires some knowledge of the nature of the pest. The sprays and the periods for spraying described in the next section are based on the principle of treating the pest population before its mid-season build-up. There are still other possibilities, but unless the controls are applied with due regard to growth stages and peculiar habits of the pest, the results are apt to be poor.

Each generation of the twig borer involves four developmental stages: egg, larva (worm stage), pupa, and winged moth. There are as many as four generations in a season. Two complete generations occur on all hosts, and there is a substantial third generation on hosts having fruits that ripen late. On very late varieties of peaches, a small part of the population completes a fourth generation.

Wintered larvae, which complete development shortly after bloom, transform into moths during April and May. The eggs laid by these moths represent the first period of reproduction. Worms hatched from eggs during May are those of the first or "May" generation. This brood is fairly distinct. The later ones overlap so that, in August and September, worms of various ages are present in late-bearing orchards.

Characteristic injury to kernels of Nonpareil almonds, and, right, Simms peaches injured by twig borers during August.

Differences in the working period of the twig borer are illustrated below, in the extreme cases of apricots and late cling peaches (Levi, Phillips, Gomes, Stuart).

On apricots

Larvae of the first generation usually appear in the foliage of apricots in mid-May, although stragglers of this brood can sometimes be found a month later. When larvae of the second generation hatch in peak numbers during July, the apricots have usually been picked and the larvae are obliged to forage on twigs or bark. Many of these immediately dig into the bark and stop growing for the remainder of the season. Others finally complete development on twigs.

It is hard to find any larvae on new growth during August. Wilted apricot shoots are rarely seen at this time of year. The onset of the inactive, bark-inhabiting phase accounts for an abrupt decline of twig borer populations after late July. Since there is therefore little reproduction after mid-season, the populations of twig borers in apricot orchards are generally not heavy.

On peaches

In the case of peaches, worms of the second generation appear when varieties such as Shasta and Fortuna are being harvested. However, the infestations continue to build up because the moths move into other, later varieties. In districts having extensive plantings of late peaches, a large fraction of the twig borer population completes a third generation. Maturing larvae of a fourth generation are occasionally found in twigs during September.

These eggs were laid on immature leaves of a peach shoot. Enlarged about 6 times.

Nectarines and almonds

The seasonal cycle on nectarines and almonds includes two complete generations—May and July—and a partial third. That is, not all of the larvae of the third (August) generation mature and produce moths. Large numbers of young third-brood larvae penetrate the bark and stop growing. The maturing individuals forage on almond trees until the hulls of the last hardshell varieties begin to dry.

The proportion of each generation of larvae that bore into bark increases as the season advances until, in late summer, when twigs are hardened and fruits are gone, all are established in cells.

Inclusive dates on which initial phases of the cyclical activities have been observed are given in table 2.

Area problems

When orchards are planted close together, the outside rows of the less severely infested orchards tend to yield more damaged fruit than the inside rows. This happens because moths flying in from more heavily infested orchards first alight on the marginal trees and deposit their eggs near-by.

Although the most serious losses are sustained by peach growers, the densest populations of the twig borer occur in almond orchards. The latter can support a relatively large population of twig borers, often without its affecting the salability of the nut crop. Much of the damage to almond fruits is confined to the flesh of the hulls and is therefore unimportant. Almond producers sustain losses only

when the larvae damage the kernels of the softshell varieties.

The majority of larvae that hatch from eggs laid when nuts are dry enough to knock go directly into hibernacula (winter cells) and do not forage. Nuts left to dry on trees in preparation for ground harvesting with pick-up machines are more or less immune to further damage by the twig borer.

On the other hand, the flesh of stone fruits is wholly vulnerable, and a lesser population of moths may produce critical losses. It often happens that almond orchards that do not need spraying for wormy meats serve as sources of infestation for near-by peaches or apricots. If the latter require spraying, then at least the bordering parts of adjacent almond and prune orchards should also be treated if possible.

Oriental fruit moth

The Oriental fruit moth (OFM), *Grapholitha molesta* (Busck), is a pest very similar to peach twig borer, for which growers must be alert. Known to be present in California, it may yet prove an important pest of stone fruits, especially peaches. The larvae of this recently introduced species behave so like the larvae of the true peach twig borer that the two pests are apt to be confused. Both species bore out the terminals of tender shoots in like manner.

Carefully examine the larvae from twigs or fruits whenever possible. The more mature larvae of the peach twig borer are brown to chocolate, with the dark color disposed in rings encircling each segment. Larvae of the OFM tend to be milky white when very small; those about one-half to five-eights inch long may be cream, flesh, or pink in color. All larvae found in mined twigs during March will be peach twig borers, but thereafter the twigs may be mined by either of the two pests.

Table 2. Initial Stages of Peach Twig Borer Activities Have Been Observed in the Sacramento Valley, California, on These Dates

Stages	Peach		Almond	
	Inclusive dates	Average dates	Inclusive dates	Average dates
First larvae resume feeding under bark (winter generation)	Feb. 20–Mar. 16	Mar. 4	Jan. 20–Mar. 6	Feb. 14
First wilted shoots	———	———	Mar. 7–Mar. 20	Mar. 14
First pupa (winter gen.)	Mar. 29–Apr. 6	Apr. 2	Mar. 22–Apr. 18	Apr. 3
First moths (winter gen.)	Apr. 15–Apr. 18	Apr. 11	Apr. 14–May 11	Apr. 29
First larva of May brood (first generation)	May 4–May 19	May 12	May 2–June 7	May 11
First pupa of May brood (first generation)	June 3–June 7	June 5	May 22–June 22	June 6
First moths of May brood (first generation)	June 15	———	May 31–July 6	June 20
First larva of midsummer brood (second generation)	June 24	———	July 1–July 16	July 6
Larvae feeding on nuts (second and third generations)	———	———	July 2–Aug. 27	———
Seasonal activity completed	Oct. 18	———	Sept. 1–Sept. 30	Sept. 12

Data recorded by Wymore (1932), Jones and Smith (1933), S. F. Bailey (1938–47).

Larvae tunnelling into the deep-lying tissues or pits of stone fruits should be regarded with suspicion. The twig borer most commonly makes superficial tunnels in ripening fruits, whereas the OFM is more apt to attack green fruits and to burrow around the area of the pit or kernel.

What to do about the twig borer • choice of sprays • why spraying at different times is necessary

For best control of twig borer infestations apply insecticides early in the season. Since there are several periods during which it is most practical to use these, and since there are a number of available chemicals, you may select alternatives that best fit with the spray operations required for control of diseases, mites, or other insect pests.

One spray should be applied before or immediately after bloom, and/or one spray should be applied in May.

How much worm damage occurred in last year's crop? The answer to this question should be the basis for deciding whether to use one or two sprays during the season. Experience indicates that one well-applied spray is enough for very light, or trace, infestations—whenever crop losses have been trivial for several seasons in succession. Low-grade infestations of this kind are apt to become troublesome if controls are omitted or poorly applied. The single treatment can be directed against worms of the overwintered generation (delayed-dormant or pink bud or popcorn spray) or against those of the first generation (May spray). The May spray is not desirable for early-ripening fruits on which residues may persist.

Two sprays are advisable for peach, almond, or prune orchards in distress, as judged by appreciable crop damage in the preceding year. One of the sprays is applied either before or immediately after bloom and the second in May.

Insecticides

Those especially serviceable for controlling twig borer are basic lead arsenate and DDT. Parathion and dinitrophenates are advantageous in some cases where twig borer is not the only consideration. These materials are listed below as options for appropriate periods. The dosages are given as amounts of formulated material needed for 100 gallons applied in conventional or bulk sprays. These concentrations have been used successfully in commercial bulk sprays with volumes varying from 450 to 600 gallons per acre.

The gallonage and quantities of materials may be adjusted for semi-concentrate methods of application according to data published by Borden (*California Agriculture*, January, 1952).

Sprays applied during the delayed-dormant, pink bud, popcorn, or petal fall periods are essentially treatments applied at different growth periods to larvae of the same (overwintered) generation.

Reasons for spraying at different periods

Delayed-dormant sprays. Spraying in the late-dormant period has several disadvantages in the control of twig borer. Larvae inactive in their cells are apparently less susceptible to toxicants than when they resume feeding activities while still in the burrows. Coverage must be very thorough to wet the larvae hidden in bark cells hard to spray. Residual in-

secticides applied very early weather-off to some extent before the larvae desert the winter cells and contact or chew on spray-covered parts of the host. In spite of these limitations, early pre-bloom sprays fit into some control programs and, with reasonable care, can be made to give good results.

The dinitrophenol compound, triethanolamine dinitro-0-secondary-butylphenate (DN-289, Elgetol 318), is appropriate for use on almonds and prunes (but not on peaches or nectarines) as a general-utility cleanup spray affecting winter eggs of mites and aphids as well as twig borer. The dinitrophenol compounds kill wintering larvae within their cells. The sprays should wet all surfaces of the main limbs and trunks as well as brushwood. We have as yet no information covering possible uses of dinitro compounds for twig borer on apricots.

In the San Joaquin Valley and in parts of the Sacramento Valley having comparable winter temperatures and rainfall, basic lead arsenate can be applied with good effect somewhat earlier than in the pink bud stage. This is sometimes done

CHOICE OF SPRAYS

	Amounts for 100 gallons
I. Near-bloom sprays (Use only one)	
Delayed-dormant	
DN-289 or Elgetol 318 (almonds, prunes)	2 quarts
or	
DDT 50 per cent wettable	2 pounds
or	
Basic lead arsenate	4 pounds
or	
Parathion 25 per cent wettable plus dormant old emulsion	2 pounds plus 3 gallons
Pink bud or popcorn	
DDT 50 per cent wettable	2 pounds
or	
Basic lead arsenate	4 pounds
Petal fall	
DDT 50 per cent wettable	2 pounds
or	
Basic lead arsenate	4 pounds
or	
Parathion 25 per cent wettable	2 pounds
II. May spray (Use only one)	
Basic lead arsenate	4 pounds
or	
DDT 50 per cent wettable	2 pounds
or	
Parathion 25 per cent wettable	2 pounds
III. Supplemental or preharvest treatments (Use only one)	
DDT 5 per cent dust, with or without sulphur	30–40 pounds per acre
or	
30–70 dust (30 per cent basic lead arsenate plus 70 per cent sulphur)	40–50 pounds per acre

when a dormant oil spray for mites or scale insects is used as the vehicle. The timing must be appropriate for the application of winter oil.

Experimental work shows that DDT can also be used effectively as early as the delayed-dormant period (table 3).

Parathion and dormant-oil-spray mixtures are not suggested primarily for controlling twig borer. This potent combination has a special use in the hands of competent spray operators for combatting infestations of olive (*Parlatoria*) scale on stone-fruit trees. However, it is very effective in destroying hibernating twig borer larvae and wintering mite eggs. If this scale treatment is used, no other twig borer spray need be applied in pink bud or petal fall periods.

Pink bud or popcorn sprays. Growers who rely on pre-bloom applications of fungicides to peaches and almonds, and who do not put on a petal fall spray for diseases, mites, or other insects, find it convenient and economical to incorporate basic lead arsenate or DDT in the fungicide spray. Both of these materials are compatible with Bordeaux, neutral or basic coppers, and iron or zinc dimethyl dithiocarbamate fungicides. Recent investigations on miticides have shown that it is also possible to include one of several sulphonate miticides (Ovotran, Genite 923) in pink bud or popcorn sprays in order to control brown almond mites on almonds and peaches.

Pink bud sprays are often used on peaches in the interior valleys, whereas the popcorn sprays are well adapted for almonds. Pre-bloom sprays are not the best choice for twig borer control on apricots, plums, or prunes because the timing is premature for other worms usually associated with these fruits. Furthermore, the pink bud spray is not regarded as the most effective against twig borer in the Santa Clara Valley and in cool coastal sections.

Petal fall spray. A spray applied in the advanced petal fall period is possibly the most profitable single treatment for

Table 3. Results of Pre-bloom Sprays of DDT Applied to 4-year Almond Trees, Arbuckle, California

Materials per 100 gallons spray	Number of strikes on 10 trees*		
	Sprayed 2/2 (delayed dormant)	Sprayed 2/14 (pre-pink)	Sprayed 2/24 (pink bud)
Check	87	129	148
DDT 50 per cent wettable, 1 lb.	3	3	0
DDT 50 per cent wettable, 2 lb.	0	0	0
DDT 50 per cent wettable, 4 lb.	1	0	0
Check	47	107	123
DDT 25 per cent emulsible concentrate, 1 qt.	0	0	0
DDT 25 per cent emulsible concentrate, 2 qt.	5	0	0
Check	129	245	123
DN–289, 2 qt.	9		
Check	91		

* Strikes counted five weeks after full bloom.

twig borer on stone fruits. Fresh deposits of insecticide are thus provided at the critical time when larvae are beginning to forage on starting shoots and floral parts. The volume of spray needed to cover the small leaves is less than that required for a later, May spray. And—especially important for apricots, plums, and prunes—the petal fall spray serves as the initial treatment for a variety of other insects. DDT sprays, as applied primarily for thrips, or parathion (wettable) applied for bud moth also give excellent results for twig borer.

Older publications on sprays refer to a "jacket" spray for twig borer. Since the jacket is not shed by young fruits for several weeks after petal fall, this term is confusing about when to begin spraying. No precise data are available to show the relation between delayed timing and reduced kill, but indications are that sprays delayed until two or three weeks after petal fall are too late for maximum value. In the period before spraying, some of the half-mature larvae are apt to escape exposure to the insecticide—especially lead arsenate—because they bore into and remain within the stems of larger twigs until feeding is concluded.

To minimize the killing of honeybees and other essential pollinators, postpone starting the spray operation until petal drop is well advanced (90 to 100 per cent petal fall) on the variety having the latest flowering date. For example, spray all of the almonds in one planting when blossoms fade on the variety last to bloom. Follow the same procedure for each of the different hosts.

May spray. Another favorable opportunity to spray for twig borer arises when the eggs of the first generation begin to hatch during May. In the case of peaches and nectarines, this spray is commonly used to apply sulphur for the control of powdery mildew.

The time interval during which control measures can be applied for maximum effectiveness against twig borer is comparatively short. The timing of this application is the same for different hosts, but the date varies from season to season (table 2, page 9) and cannot be readily established beforehand.

Questions about the comparative values of single sprays applied in the different periods of growth—pink bud or petal fall or May—cannot be answered simply. When almond and peach trees were sprayed with lead arsenate during each of these growth periods and the numbers of worm-damaged shoots counted within two to four weeks after each application, the differences due to the timing were not significant. Each application killed about the same number of worms (tables 4, 5). Similar results were obtained for DDT and parathion sprays.

Another method was used to determine the effectiveness of differently timed sprays. In this series of experiments, lead arsenate sprays were applied to almond trees in the petal fall and May periods, but the results were tabulated as percentages of almond kernels damaged at harvest time. Averages for six seasons of plot trials show that the lead arsenate sprays applied in May tend to yield more worm-free nuts than when the sprays are applied at petal fall (table 6). The method of counting damaged shoots a short time after spraying is especially useful for comparing insecticides, whereas the method of counting damaged kernels gives a more conclusive measure of ultimate effects of spraying on the insect population during the whole period of crop production.

Timing May sprays. It has been the custom of Farm Advisors and other competent observers in the principal peach-producing sections to determine the time for applying May sprays. The date is announced locally as soon as determined.

Twig borers developing in May feed mostly on succulent shoots. The success of the May spray, therefore, depends upon the application of materials before eggs of the May brood hatch in peak

Table 4. Effect of Single Sprays Applied to 3-year Almonds in Post-bloom Periods, Arbuckle, California

Materials per 100 gallons spray	Number of strikes on 10 trees	
	After petal-fall spray	After May spray
Check	194	145
Basic lead arsenate, 4 lb.	16	24
DDT 50 per cent, 2 lb.	4	2
Parathion 25 per cent, 2 lb.	8	5

Petal fall sprays applied March 26, 50 gal. per 20 trees per plot; strikes counted March 13. May sprays applied May 20, 50 gal. per 15 trees per plot; strikes counted May 27. First larvae of "May" generation found on May 14.

Table 5. Effect of Single Sprays Applied to 3-year Elberta Peaches in Pre- and Post-bloom Periods, Hughson, Stanislaus County, California

Materials per 100 gallons spray	Number of strikes on 10 trees		
	After pink-bud spray	After petal-fall spray	After May spray
Check	189	208	176
Basic lead arsenate, 4 lb.	78	83	67
DDT 50 per cent, 2 lb.	0	4	13
Parathion, 2 lb.	0	8	4

Pink bud sprays applied March 17, 100 gal. per 56 trees per plot; strikes counted April 8. Petal fall sprays applied April 1, 100 gal. per 48 trees per plot; strikes counted April 13. May sprays applied May 24, 100 gal. per 30 trees per plot; strikes counted June 6. First "May" larvae appeared May 16.

Table 6. Average Percentages of Worm-infested Nonpareil Meats Harvested from Plots of Almonds Sprayed with Basic Lead Arsenate, Arbuckle, California*

	1937	1938	1939	1940	1941	1942	Mean of averages
Check	7.3	35.0	1.5	2.1	20.8	8.4	12.5
Petal fall spray only	5.3	20.5	1.8	2.7	18.0	....	9.6
May spray only	3.7	11.4	1.6	2.2	17.9	4.2	6.8
Petal fall plus May spray	3.0	9.1	1.4	....	....	....	....
July spray	....	....	....	....	19.3	4.5	....

* Bulletin 708, Bailey, 1948.

numbers. Hatching normally begins on May 11–12 in the central valleys, and the increase in the number of damaged shoots—new entries—levels off about June 1. Spray materials applied within 5 to 10 days after hatching begins appear to give best results.

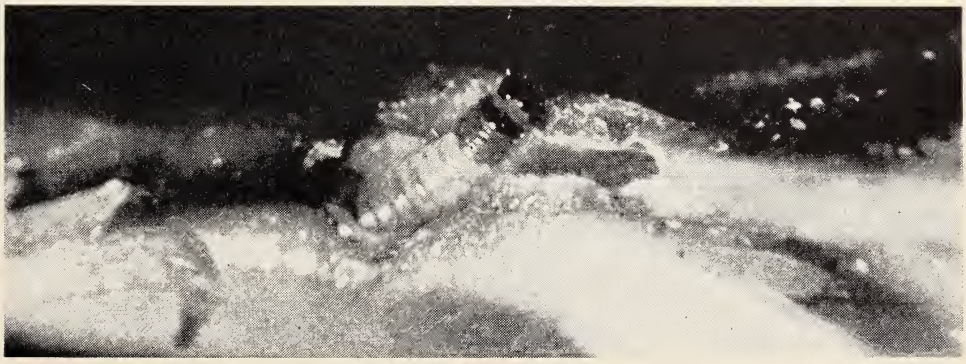
The timing of this spray is best accomplished by observations made on unsprayed, small almond or peach trees—two to three years of age—that are known to be well infested. At least there should be numerous signs of terminals killed back by worms of the preceding brood. Begin looking for new strikes during the first week of May and continue at intervals of about three days until you find the first newly hatched larva. If additional strikes are found within the next day or so, you are reasonably sure that the hatching of the oncoming brood is under way but not advanced.

The object is to find very small larvae in initial stages of development that have not had time to work far down into the core of the twigs. Disregard drooped or dying shoots already deeply mined by larvae of the earlier brood. The new strikes most often seen are those in which entries are made through the petioles of the newest leaves. A single wilted leaf is the clue to the presence of a tiny larva. The smallest larvae are most easily found on almond and peach trees. They are very hard to notice on apricots, plums, or prunes.

The first obvious sign of an attack on an almond shoot by a newly hatched larva. Point of entrance is marked by a few granules of excrement and webbing between the stem and petiole of the first well-developed leaf on the left.

There is an identifiable break between the overwintered brood and the May brood of larvae. Stragglers of the overwintered brood can sometimes be found in twigs during the early part of May. All are nearly mature individuals about to conclude the twig-boring phase. These disappear from the foliage about two weeks before the new hatch begins. Prolonged periods of below-average temperatures during April can delay the maturing

Photomicrograph of a very young larva partly dissected out of its burrow in the tip of a young peach shoot. Enlarged about 6 times.



period of the brood to follow. For example, during the spring of 1948, worms of the overwintered generation persisted in the feeding phase until about May 20, while the next brood did not appear until June 7.

Supplemental treatments

A difficult problem in control arises when ripening fruits are found to be severely infested with worms—especially fruits of table varieties not subject to washing or processing before going to market. At present, no method can be suggested for disinfesting nectarine, apricot, plum, or prune orchards at this late date, because of the probability of adulteration with poison residues.

Growers of cling peaches have been able to get partial relief late in the season by dusting infested orchards with basic lead arsenate and sulphur "30-70" dust. Since 1947, 5 per cent DDT dust has been applied in many cling-peach orchards where many worms in the first varieties to ripen indicated more trouble later. Trained observers and growers believe that DDT dust gives better protection than 30-70.

The usual procedures for peeling peaches in caustic soda solution should eliminate or reduce to trace level in the canned product the residues of the lead arsenate or DDT dusts. The possibility of contaminating the canned fruit in some degree by pre-harvest treatments depends upon time and mode of application, amounts of toxicant deposited, and method of processing.

It is best to depend upon earlier sprays for worm control—at least until a pre-harvest treatment can be perfected that is satisfactory in all respects.

A limited amount of experimental work was done some years ago with shortlived botanicals—rotenone and fixed nicotine—applied to plums. Older recommendations made by the University included these botanicals, but growers have used them too rarely to show their value. Whether the results justify the expense is not established.

Lead arsenate or DDT?

Bulk sprays of basic lead arsenate, four pounds per 100 gallons, reduce the number of strikes 78 to 92 per cent; while comparable sprays containing two pounds of 50 per cent DDT per 100 gallons have yielded values not less than 93 per cent reduction of strikes. There is therefore no question about the superiority of DDT over basic lead arsenate for reduction of twig borer populations, but unfortunately DDT also kills many of the desirable or beneficial insects, which prey on aphids, scale insects, red spider mites, moths, etc. Lead arsenate does not appreciably affect the parasites and predators in a direct way.

Possibly there is least harm to beneficial insects when DDT is applied early in the growing season, before or immediately after bloom. The wisdom of substituting DDT for lead arsenate in sprays regularly applied during May—or later—is still not settled.

Some processors of peaches for baby foods prefer DDT over lead arsenate for use in sprays applied during May. One reason for this relates to difference in stability of the two spray chemicals. Lead arsenate is the more stable compound, and traces of its toxic elements persist for a much longer period than the useful life of the compound. The preparation of baby foods can offer a problem in this respect because some variations of the peeling process do not insure complete elimination of all traces of the lead arsenate.

12m–11,'55(B1657)A.A. 141

Co-operative Extension work in Agriculture and Home Economics, College of Agriculture, University of California, and United States Department of Agriculture co-operating. Distributed in furtherance of the Acts of Congress of May 8, and June 30, 1914. J. Earl Coke, Director, California Agricultural Extension Service.